



US006265031B1

(12) **United States Patent**  
**Ishii et al.**

(10) **Patent No.:** **US 6,265,031 B1**  
(45) **Date of Patent:** **\*Jul. 24, 2001**

(54) **METHOD FOR PLASMA PROCESSING BY SHAPING AN INDUCED ELECTRIC FIELD**

(75) **Inventors:** Nobuo Ishii; Jiro Hata, both of Yamanashi-ken (JP)

(73) **Assignee:** Tokyo Electron Limited, Tokyo (JP)

(\*) **Notice:** This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** 09/252,002

(22) **Filed:** Feb. 18, 1999

**Related U.S. Application Data**

(62) Division of application No. 08/788,636, filed on Jan. 27, 1997, now Pat. No. 5,938,883, which is a continuation of application No. 08/180,281, filed on Jan. 12, 1994, now abandoned.

(30) **Foreign Application Priority Data**

Jan. 12, 1993 (JP) ..... 5-019193  
Jan. 12, 1993 (JP) ..... 5-019217  
Mar. 27, 1993 (JP) ..... 5-092511

(51) **Int. Cl.<sup>7</sup>** ..... H05H 1/16  
(52) **U.S. Cl.** ..... 427/460; 427/569; 427/571  
(58) **Field of Search** ..... 427/569, 576,  
427/577, 460, 571

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,886,896 6/1975 Van Cakenberghe .  
4,292,153 \* 9/1981 Kudo et al. .... 427/570

4,434,742 3/1984 Ilenaff .  
4,539,068 \* 9/1985 Takagi et al. .... 427/570  
4,948,458 8/1990 Ogle .  
4,985,109 \* 1/1991 Otsubo et al. .... 427/575  
4,989,542 \* 2/1991 Kamo ..... 427/575  
5,091,049 2/1992 Campbell .  
5,180,435 1/1993 Markunas .  
5,277,751 1/1994 Ogle .  
5,304,279 4/1994 Coultas .  
5,401,350 3/1995 Patrick et al. .  
5,433,812 \* 7/1995 Cuomo et al. .... 156/345  
5,556,501 \* 9/1996 Collins et al. .... 204/298.34  
5,560,776 \* 10/1996 Sugai et al. .... 118/723 I

**FOREIGN PATENT DOCUMENTS**

0 379 828 8/1990 (EP) .  
4-290428 10/1992 (JP) .

**OTHER PUBLICATIONS**

Hideo Sugai, Kenji Nakamura and Keiju Suzuki, Electrostatic Coupling of Antenna and the Shielding Effect in Inductive RF Plasmas, Apr. 1994, pp. 2189-2193, Jpn J. Appl. Phys. vol. 33 (1994), Part 1, No. 4B.

\* cited by examiner

*Primary Examiner*—Shrive Beck

*Assistant Examiner*—Bret Chen

(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

A method for achieving a highly uniform plasma density on a substrate by shaping an induced electric field including the steps of positioning the substrate in a processing chamber, supplying a high frequency power to a spiral antenna generating an induced electric field in the processing chamber, generating a plasma in the processing chamber, and shaping the electric field with respect to the substrate to achieve a uniform distribution of plasma on the substrate being processed.

**7 Claims, 14 Drawing Sheets**

